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IOWA GEOLOGICAL SURVEY

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A DESCRIPTION

OF

THE REGION ABOUT CAMP DODGE

By

JAMES H. LEES
Assistant State Geologist

GEORGE F. KAY
State Geologist

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DES MOINES:
Published for Iowa Geological Survey
1918

LETTER OF TRANSMITTAL

IOWA GEOLOGICAL SURVEY

To Governor William L. Harding and Members of the Geological Board:

Gentlemen: I submit herewith a report entitled "A Description of the Region about Camp Dodge", and recommend that it be published as a special bulletin of the Iowa Geological Survey.

In this report there will be found descriptions and interpretations of the topography and geology of the region in which thousands of the young men of our state and other states are receiving their military training for service beyond the seas. It is hoped that the information which is presented, together with the topographic map which accompanies the report, will enable the soldiers and other persons to understand more fully than they otherwise could have done the influence of the natural features of the region upon military training and maneuvering, and upon many of the other activities of the camp. The report should serve also to emphasize the well known fact that wherever military operations are being carried on and war is being waged there is an intimate relationship between the topography and geology of the region and the movements of the armies. The mountain, the hill, the cliff, the plain, the valley, the swamp, the soil, the underlying rock, each of these plays its part in connection with the activities of artillery, of cavalry, and of infantry, the digging of trenches, the furnishing of water supply, and in many other ways.

The report was prepared by Dr. James H. Lees, Assistant State Geologist. Similar reports have been undertaken at various army camps throughout the United States at the suggestion of the Geology and Paleontology Committee of the National Research Council after conference with prominent military men.

Respectfully submitted,

GEORGE F. KAY, *State Geologist.*

A DESCRIPTION OF THE REGION ABOUT CAMP DODGE

INTRODUCTION

The region about Camp Dodge, or more exactly, the vicinity of Des Moines, has a certain military interest because here was located one of the early army posts which preceded and accompanied the permanent settlement of the Des Moines valley and the bordering upland prairies. In order to prevent disturbances between the hostile Indian tribes of central Iowa and also to check the activities of a band of outlaws which was committing depredations in the vicinity, the War Department in 1842 issued orders for the establishment of a military post at the junction of Des Moines and Raccoon rivers. Captain James Allen of the First United States Dragoons ascended the river from Fort Sandford, near the present site of Ottumwa, in November of the same year and selected a location for the proposed post. In the spring of 1843 Captain Allen returned with a company of infantry and one of cavalry and established the fort along the west bank of the Des Moines near the present line of Second Street. He named the post Fort Raccoon, but General Scott did not approve of this name and ordered it changed to Fort Des Moines. This post was maintained until 1846, by which time the Indians had ceded their lands to the government and had moved beyond Missouri river. The Indian lands were then opened to settlement and the fort was abandoned. The Daughters of the American Revolution maintain a stone monument here and a flag still floats over the former site of old Fort Des Moines.

A second military post was established near Des Moines only a few years ago, chiefly through the untiring efforts and personal influence of Captain J. A. T. Hull, who for twenty years represented this district in Congress. Captain Hull began working for the establishment of an army post at Des Moines in 1894, but it was not until 1903 that he saw the successful issue of his labors and the new Fort Des Moines was completed and was occupied by a regiment of United States Cavalry. This post has been occupied almost continuously since its completion by various cavalry units and more recently as a training station for colored army officers. At present it is being used as a convalescent army hospital.

When the United States entered the European war—or as it is well called, the world war—and it became necessary to establish training camps for the assembling and drilling of the American armies, Des Moines was chosen as the location of one of these camps and it was named Camp Dodge. A small part of the present Reservation had been used for a number of years as a National Guard camp and this was made the basis of the larger National Army Cantonment.

Naturally geographic location has been an important factor in determining the strategic value of the successive army posts which have been established in the vicinity of Des Moines. In Captain Allen's day among the decisive points were the facts that here converged several primitive lines of travel—those along the Des Moines and Raccoon valleys; that the junction of these valleys would afford an excellent camp site—the reservation included only one square mile; and that here timber, grass and other forage and food supplies could be obtained in abundance. When the second Fort Des Moines was established its location was determined by the presence of a fine level stretch of land close enough to drainage lines to allow of excellent sanitation and also close enough to a large and healthily growing city to provide for the social and economic needs of the post. In determining the location of Camp Dodge it was necessary not only to secure space for the accommodation of a great body of troops, many times greater than had ever been stationed here in the past, but also to meet the very important questions of a sufficient supply of pure water and of an adequate system of sewage disposal. Then there is the further problem of available territory in the vicinity of the Cantonment which shall be suitable for the drilling and training of the soldiers-to-be. All of these questions are closely connected with the geography of the region about Camp Dodge and a knowledge of this geography will be helpful in understanding these and the many other problems which arise in connection with the carrying on of military plans. An understanding of the geographic forms of the region and of their mode of origin will serve also to give an added interest to the experiences of camp life and will give a more intelligent outlook upon the natural features about the Cantonment.

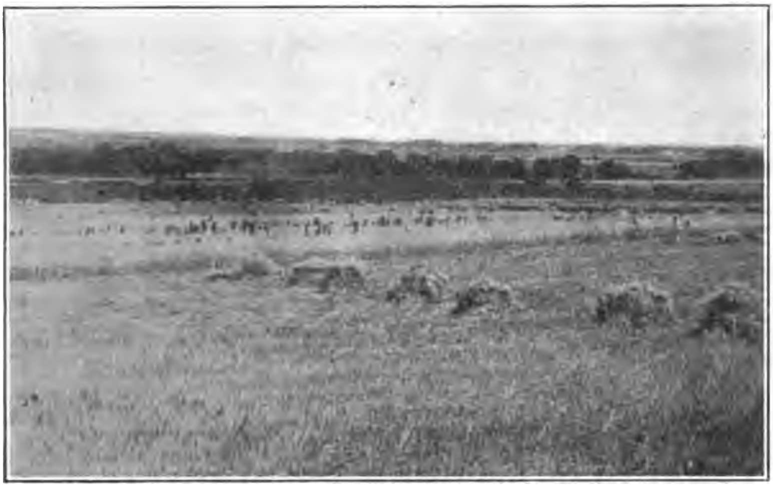

FIG. 3—Looking southeast down Beaver valley from the center of section 34, Jefferson township. The view shows the very gentle slopes and the wide flat floor of the valley—the ancient course of Des Moines river. The village of Johnston is visible in the distance in the valley.

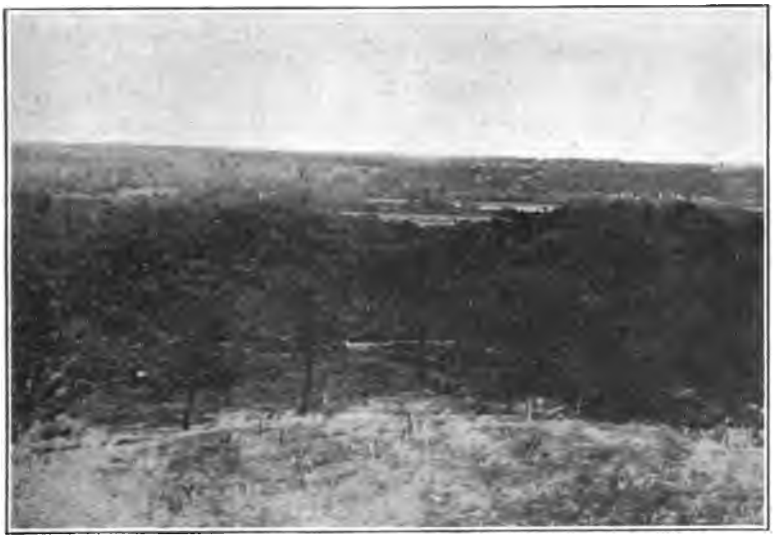

FIG. 4—Looking north of east across Des Moines valley from the top of the west wall near Dodge City. This shows the steep slopes and the flat valley floor, which is narrower than that of Beaver valley, just to the west, although the river is much larger than the creek.

THE TOPOGRAPHIC MAP

The surface features of Camp Dodge and the surrounding region are well shown on the accompanying map by means of brown lines which are called contour lines. A contour on the ground passes through points having the same elevation above sea level and therefore one who follows a contour goes neither uphill nor down, but always on a level. A line drawn through these points is then a contour line. Where the lines are far apart, as in Beaver valley in and south of Camp Dodge Reservation and in Des Moines valley opposite the mouth of Beaver valley, they show that the land is very flat. Where they are closer together, as along the west wall of Des Moines valley near the Cantonment, they indicate steep slopes. If the lines are relatively straight they indicate a smooth, even surface, but where they are irregular and curve back and forth they show that the surface is cut up by numerous ravines and other irregularities. Good examples of these features are shown within the Cantonment, as for example where the slightly wavy contour lines of the map show the smooth, gently sloping east wall of Beaver valley on which the main part of the Camp is built, a slope which flattens out to the north in the region of the base hospital, near the tiny red triangle which indicates the location of Herrold. The crowded, exceedingly irregular contours marking the west wall of Des Moines valley —the east slope of the dividing ridge—show that this slope is steep and gashed by many gullies and ravines. The remount station, on the west side of Beaver creek, occupies a tract with a very gentle slope from the northwest as is shown by the rather widely spaced contours; while the rifle range, in the wide loop of the river in Des Moines valley at the southeast corner of the Reservation, seems to be on almost level ground, as not a contour crosses it.

On the map of the Camp Dodge region one inch represents approximately one mile of horizontal distance. That is, the scale of the map is about a mile to an inch, or as it is stated on the map, 1:62,500, one inch on the map being equal to 62,500 inches on the ground. The interval between successive contour lines represents a vertical distance of twenty feet. Therefore in passing over the space on the ground represented on the map by the distance between two contour lines one would change his elevation twenty feet.

Military maps, on the other hand, are customarily made on scales of three, six or twelve inches to the mile and the contour interval is twenty, ten or five feet respectively. Such maps are intended to show small areas in great detail, to permit of the insertion of many items of importance in planning battles and campaigns. The ordinary topographic map, such as this of Camp Dodge, covers a large area, on a smaller scale and in less detail, it is true, but it permits the examination of much more territory than does the map of the smaller area and it enables the observer to plan long marches, to select the best routes of travel, even to lay out preliminary railway grades, drainage ditches, sewers and many other improvements.

It will be seen then that a contour or topographic map enables one to determine not only the positions of towns, rivers, roads and other features but also the character of the surface, the height and slope of the hills, the depth and width of the valleys and the shape and size of all topographic forms which can be mapped by means of twenty foot contour lines. Frequent reference to the map with these points in mind will help greatly in understanding the geography of the region about the Camp.

SURFACE FEATURES

To the soldier and the military strategist every element of topography has its special significance and value. True the surface features about Camp Dodge will not be the same as those on the western front, but the features here at home may teach the military man just as effectively as will those over there the lessons he needs must learn and will give him equal opportunity for planning his campaigns and laying his strategy. It can not be impressed too deeply on the mind that an intimate knowledge of topography is one of the essentials to success in military operations, as indeed is true of every form of natural features. For instance in one of the eastern campaigns among the swamps of Russia and East Prussia the Germans, whose expert observers were familiar with swamp vegetation, were able to cross certain swamps because they knew that the plants of these swamps grew up from a sandy bottom. The Russians, on the other hand, were unfamiliar with these conditions and on attempting to cross certain swamps in their vicinity were mired in the soft mud bottoms. Again the violation of Belgian neutrality and the invasion of Belgium and northern France by a power which knew

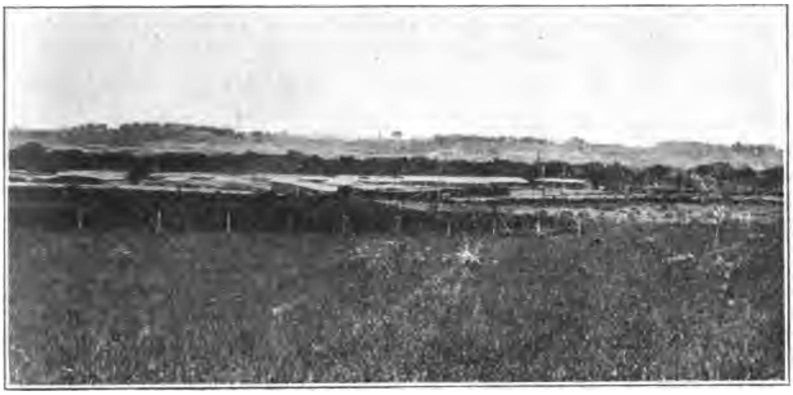

Fig. 5—Looking east across the Remount station and Beaver valley over Camp Dodge to the slopes of the Des Moines-Beaver ridge. The view is from a knoll which lies in the valley of Beaver creek in the northeast part of section 27, Jefferson township, and which belongs to the morainic system of hills of this region. Note the water tank on the crest of the ridge. The course of Beaver creek is marked by the line of trees just beyond the buildings.

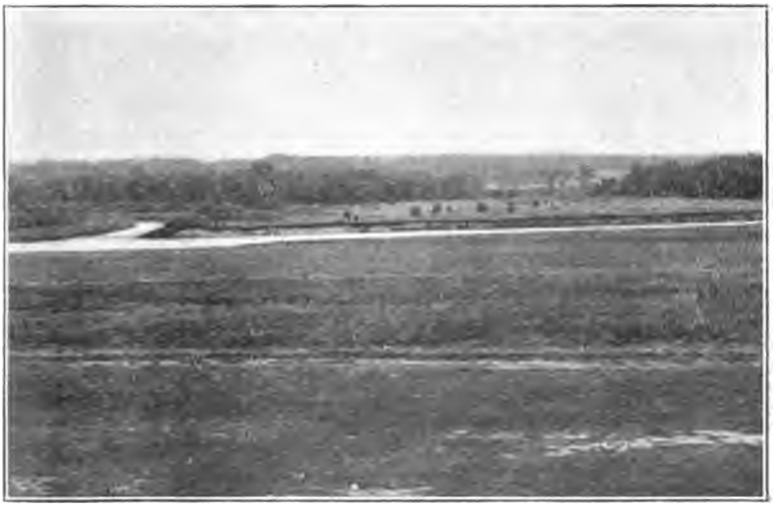

Fig. 6—Looking west across Des Moines valley opposite Camp Dodge, from the east bluff in the southwest quarter of section 29, Crocker township. The view shows the fairly wide flat flood-plain of the valley and the steep west wall, which is formed by the long ridge between Des Moines and Beaver valleys. The rifle range is just to the left of the area shown in the foreground.

no law but that of brute force were predestined by the topographic features of that region more than by any political consideration or economic necessity. The level plains with their fine systems of roads offered a gateway to Paris as well as to the wealth of France and Belgium, a gateway whose advantages overbalanced all checks of right or treaty or international approval. So it should be clear that every bit of added knowledge or added ability to interpret the forms of Nature into terms of military operation will add its share in winning the final victory on the real field of battle.

The area in which Camp Dodge is situated and which is shown on the map, may be described in brief, then, as a gently rolling prairie which is divided diagonally by the deep valley which Des Moines river has cut across it. Several smaller streams, tributary to the Des Moines, also occupy valleys which have been made in this upland. Noteworthy among these are Beaver creek, whose valley has a notable history, to be outlined later; Walnut creek, whose valley is much narrower than is that of Beaver creek; and, farther to the south, Raccoon river in a valley which rivals in size that of the Des Moines above the Cantonment. From the east there enter the Des Moines, Big creek, Rock creek, and, just east of Des Moines, Fourmile creek, each of them occupying a deep valley in its lower reaches, although in its upper portions it meanders along mere shallow prairie swales. In addition the walls of the larger valleys are gashed by many minor ravines which cut into the upland for a mile, two miles, or in a few cases three to four miles from their mouths.

It will be understood that these ravines and valleys have in most cases been cut by the streams which occupy them and hence their size bears some relation to that of these streams. It will be noticed at once, however, that Beaver valley offers an exception to this rule as also perhaps do the lower parts of Walnut, Big and Fourmile creek valleys since they seem to be much too large to have been made by the small creeks which flow along them. Evidently something out of the ordinary has happened here and what this is will be explained in the following pages.

But in spite of all these valleys and streams, large and small, it is nevertheless true that there are considerable areas of the prairie in which natural drainage lines are either not developed at all or else their positions were determined by pre-existing depressions. This, of course, is directly opposite to the more common conditions, especially those near the large streams, where the drainage lines and the irregularities of the surface have been cut, for the most part, by running water. Over the nearly level prairie the eye may gaze unhindered for miles. Only here and there in the more undulating or rougher portions may one see a great hill of irregular outline or a broad, shallow swamp, neither of which, perchance, bears any close relation to the streams of the neighborhood and neither one of which has been formed by them. If reference is made to the map it will be seen that good examples of the level upland topography are found in the region about Ankeny and Enterprise and just west of Grimes, or across Walnut creek, about Waukee, while the rough, irregular, hummocky topography is well developed along Beaver valley a few miles directly west of Camp Dodge.

The military relations and significance of these different topographic features are so clear as to need no elaboration, but they may at least be outlined here. The movement of troops across the relatively level upland prairie plain will be fairly easy but their detection by a waiting enemy will be equally easy. Such an area as that along the south slope of Beaver valley west of the Camp as far as the limit of the map with its rough hills and intervening swamps would be easier of defense and harder of attack. The rather deep, narrow valleys of Fourmile, Big and Walnut creeks with their scattered timber filling would similarly be readily defended and might be held against strong attacks—by either friend or foe. The broad valley of the Beaver and its continuation to the southeast partake more of the nature of the plain. The supreme example within the region of the tactical importance of a valley is that of Des Moines river near and above the Camp. Its broad flat bottom lands with their protective timber patches, their sand and silt filling, their bayous, meanders and cut-offs and their bridges with their long approaches, all these offer numerous strategic problems. The steep walls also with their deep and in most cases timber filled ravines or their high level terraces afford abundant opportunities for study and practice of offensive and defensive warfare, such as shielding stationary or marching troops or training in gas warfare. It is just such river valleys as this which have played such important roles on the battlefields of France. The Somme and the Oise, the Aisne and the Marne have been decisive factors ere now and will be again.

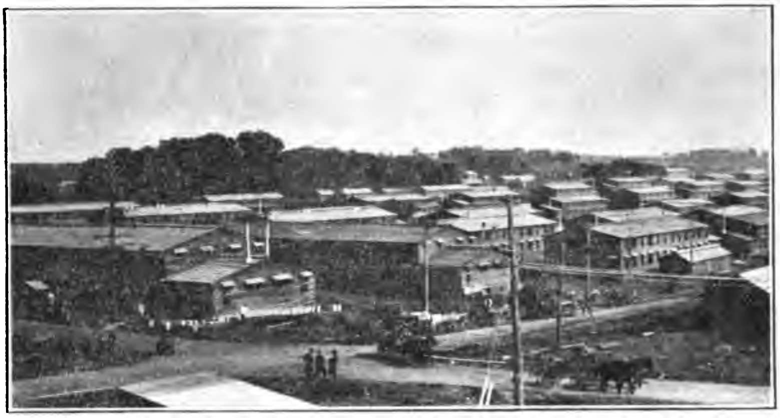

FIG. 7—Looking southeast in Camp Dodge toward Division Headquarters. The view shows the west slope of the ridge between Des Moines and Beaver valleys. The barracks of the Camp are well shown also. Photo published by courtesy of Enos B. Hunt, photographer.

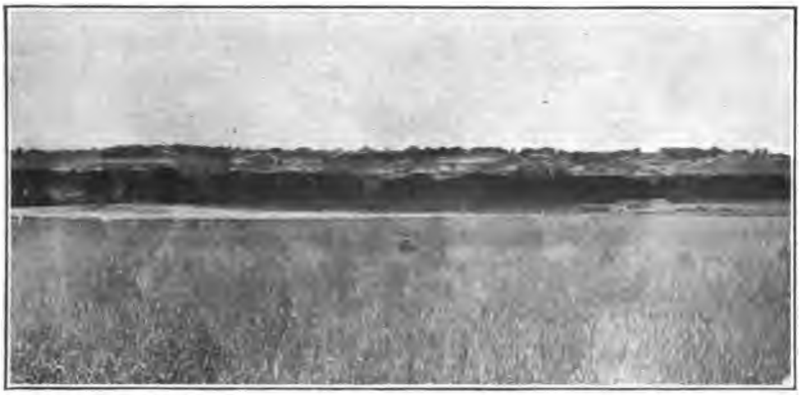

FIG. 8—Looking northeast across Beaver valley toward Camp Dodge from the southeast quarter of section 34, Jefferson township. Note the gently sloping west wall in the foreground, the broad valley and the somewhat steeper slope of the ridge on which the Camp is situated. The buildings of the Camp may be seen on this slope and the great water tank crowns the ridge.

And many of their features are shared by the peaceful valley of Des Moines river.

Another topographic feature of commanding value is the long, high ridge between the Des Moines and the Beaver which offers opportunity for so much tactical work, with its steep rugged east slope and its long gentle smooth west slope. Here again the resemblance to the French ridges is marked and significant.

SOILS AND ROCKS

The close relation which exists between the form of the surface and the soils and subsoils is well shown in the different areas already mentioned. Thus on the level prairie the surface material is a rich fertile soil—the yellow pebbly clay made loose textured and porous by the roots of plants and blackened by the generations of vegetation which have grown upon it and after death have been absorbed into it and mingled with it. In the undrained swamps and depressions, which are abundant in some parts of the uplands, notably in the northeast part of the area here described, instead of the black soil there is a peaty material which is the result of the accumulation during centuries of the remains of water loving plants. The surface material of the rough hummocky areas is prevailingly sandy and gravelly and has accumulated through plant growth less of the black material which makes the prairies so fertile. The surface material of the shallow swales along which some of the upland streams wind their ways is intermediate between the black loamy soil of the prairies and the peaty matter of the swamps. Farther down these streams and all along the Des Moines and Raccoon valleys within the area covered by the map the valleys are filled to greater or less depths with sand and gravel over which is laid a deposit of rich black alluvium, the result of wash from the hills and slopes higher up. Under all of these varying types of soils is the yellow or gray or blue-gray pebbly clay, which is everywhere present except where locally it has been cut away and the underlying rock has been reached.

Underneath all these various types of soils and subsoils, and forming the foundation upon which they are all laid is the solid rock of the region, the bedrock, so called to distinguish it from the loose overlying materials, which are the mantle rock. Under all the region about Camp Dodge the bedrock is composed of shales, beds of mud and clay which have been hardened into solid rock; sandstones, sand deposits which likewise have been cemented and solidified; and some layers of coal, the product of successive generations of plant life in the swamps and bayous of a far distant time. Comprising by far the larger part of this series of rocks are the shales, while the sandstones occupy a second though quite inferior position, and the coals constitute only a few per cent of the total thickness and bulk of the bedrock. The shales range in color from black through gray, red, brown, purple, blue and other colors to nearly white, and some of them form transitional beds from true coal to true shale, or slate as they are usually called by the miners. The black shales owe their color to carbon, which was derived from plants growing upon their surface while the beds of mud were forming, and the brighter colors are produced by iron and other minerals contained within the shales. Where the shales have been exposed for some time, as along the Des Moines valley, they have become softened and wash away easily. Also where they are encountered under the mantle rock they are in places so soft as to be distinguished from the overlying materials chiefly by their brighter colors, and sometimes not easily by that feature. The sandstones likewise have disintegrated under exposure to beds of fine, loose sand. In places, as along the riverward face of the long ridge between Des Moines and Beaver valleys, there are a few thin beds of limestone, here for the most part a dark gray fine-grained stone in layers six to ten inches thick.

In general it may be said that the bedrock of our region lies in nearly horizontal position with a slight dip or inclination of the strata from northeast to southwest, a dip which is shared by all the rocks of this part of Iowa and which amounts on an average to ten feet per mile.

Perhaps it should be explained that the different types of material in the bedrock are present in alternating layers and that the succession of beds may be repeated several times in any vertical section. It is also true that at different localities, even though these be not widely separated, the succession of strata will probably not be just the same, for various layers differ from place to place, due to the differing conditions under which they were deposited. For example there is exposed at the south foot of Capitol Hill a bed of sandstone which is twenty-five feet or more in thickness. But if this bed be traced northwestward up the river it will be seen to be thinner and finally to be replaced entirely by shale so that in the vicinity of the Cantonment there is no sandstone but only shale. The limestone bands, however, are more persistent and may be traced entirely across this region.

Scarcely less important than the topography in their relation to campaigns and all the operations of modern warfare, the soils and rocks of our region are deserving of special attention from these viewpoints. It is of considerable importance to know whether the soils to be encountered in a given direction from the Camp are such as will churn into mud in wet weather or grind into dust in dry seasons. Both of these conditions will hold good for the black soil of the prairies and some valley areas while the gravelly soil of the hummocky regions and the sandy soils of the valleys will absorb much water but transmit it rapidly and so will not be so muddy or dusty.

The character of the soils will have much to do with the matter of trenching. The black soil with its yellow or gray subsoil is easily dug and will stand well when dry. When wet it is apt to slump till its angle of rest is reached. This angle is about 30 degrees. Sandy soils will not stand so well and must be revetted. They have the advantage, however, of allowing the ready draining away of water which may enter them, while the clay soils will retain water much longer. Soils differ also in their penetrability to bullets. The general rule for the thickness of earth parapets is that it must equal the length of the rifle, but while loose sand or earth of this thickness will be sufficient protection, wet or greasy clay must be one-half thicker and dry turf or peat twice as thick. The soils of the Camp Dodge region are similar to those of Belgium and northern France and hence present the same problems to the soldier.

Operations in the bedrock are somewhat different from those in the soils. Shales are fairly easily dug and will stand well when dry, like the clay subsoils. Like them also they will slump badly when wet. The sandstone or limestone layers will be harder to dig but will stand indefinitely. If tunnelling is necessary they will stand up with less timbering than will clays or shales. The relations of the bedrock to gunfire differ also. Hard rocks like limestones will splinter and break badly under impact of shells. Shales and sandstones are more yielding and hence less dangerous. In the Camp Dodge region the bedrock will be of only slight importance owing to the almost universal presence of the soils and clay subsoils, but it may be noted that on the battle front in northern France the bedrock is of considerable importance. Here it is a chalky rock on which lie hillocks of sandstone which form the famous Vimy and Messines ridges as well as others of military renown. Like the strata of northern France, too, those of the Camp Dodge region lie nearly horizontal, though they are more variable from place to place. This is of importance in trenching, tunnelling and especially, perhaps, in the transmission of water.

HISTORY OF THE BEDROCK

It will aid in understanding the various features about Camp Dodge if we outline in brief the geologic history of this region and of neighboring parts of Iowa as well, since our area is but part of a much larger unit. A study of the accompanying outline geological map of Iowa, figure 9, which gives the areas of outcrop of the bedrock of the state, shows that northeast of Des Moines river the strata of different ages are spread out as long northwest-southeast trending bands. All of these strata extend westward from the area in which they outcrop or are immediately beneath the mantle rock, so that they overlap one another like the leaves of an open book. The southwestward dip of the strata which was mentioned previously carries the different layers to greater and greater depths with advance to the southwest, so

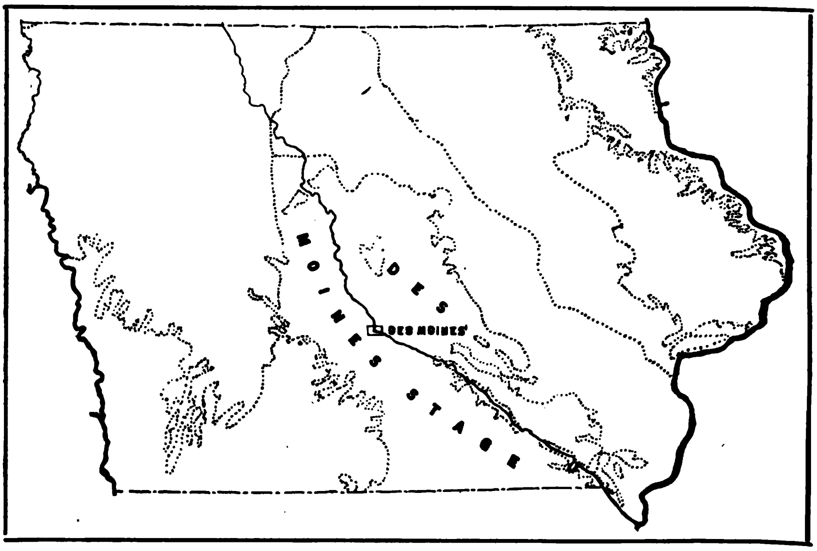

FIG. 9—Geological sketch map of Iowa showing the distribution of the strata. The rocks in the vicinity of Des Moines and Camp Dodge belong to the Des Moines stage.

that layers of rocks which in northeastern Iowa form the surface materials or rise in great cliffs above the rivers are buried hundreds of feet beneath the surface in central and southern Iowa. But all of them have been penetrated in several wells in and near Des Moines and are found to retain their essential features even thus far from their outcrop. They in turn form the foundation upon which the bedrock of central and western Iowa is laid down. They consist of great beds of sandstone, limestone and shale, which were laid down on the floors of the shallow oceans which covered the interior of North America ages ago.

Millions of years passed by during which these rocks were forming. Then there occurred in southern and central Iowa, as well as in many, many other parts of North America, conditions which were exceedingly favorable for plant growth, especially for those plants which grew in and near the water. Probably central Iowa resembled the presentday Everglades of Florida or the Great Dismal Swamp of Virginia. In these coastal swamps plants grew luxuriantly, flourished and died, but their falling stems and leaves were preserved from decay by the water into which they fell. Elsewhere beds of mud and sand were accumulating offshore and farther out in the quiet sea there were forming banks of limy ooze mingled with shells and other skeletons of lime-forming animals. In time a change of conditions put a stop to the plant growth in some of the swamps and they were buried beneath a layer of sand or mud. Then again as conditions favorable to plant life recurred another forest grew up over the buried one or over the beds of mud and sand elsewhere. Thus the cycle went on and there were piled up bed after bed of plant remains and mud and plant remains and sand and plant remains and mud in almost endless succession. But the pressure of overlying beds was consolidating the lower layers and circulating waters were carrying materials in solution which were cementing some of the beds into rock, and other changes were going on in the mass while newer layers were being formed above. So the muds were being pressed and hardened into shales, the sands were being cemented into sandstones, the limy muds were pressed and cemented into limestones, and the layers of plant remains were having their gases driven off and were solidifying into coal. The plants which had been growing in the coal swamps had removed from the soils on which they grew those minerals which formed part of their food, and as these mineral plant foods are the elements which make clays melt easily in the kiln, because of their absence these old soils are now very resistant to heat and so are known as fire clays.

We all understand how slowly beds of sand or mud are accumulating in the rivers and seas of today and so we can realize that the events just described must have consumed enormous lengths of time, extending certainly into hundreds of thousands and possibly into millions of years. It is estimated that 8000 to 9000 years would be required to produce a foot of coal. If the total thickness of the Iowa coals be estimated at forty feet, which is merely an estimate, the length of time required for their accumulation would be 320,000 to 360,000 years—provided the rate of accumulation were the same when the coals were forming as it is at present in our peat bogs. The total thickness of the beds associated with the coal, called on the map the Des Moines stage, is about 500 feet near Des Moines. These deposits must have required fully as much time for their accumulation as did the coals. Hence we must at least double the figures already given. Then too these strata are very much thicker than 500 feet in some parts of North America, so that the duration of this period of coal formation is estimated at 2,000,000 to 5,000,000 years.

While these rocks of the Des Moines stage, or as we also call them, the Coal Measures, are best developed in central and south-central Iowa, they are known to have covered all of southeastern Iowa, as far as Mississippi river. During the enormous length of time since the rocks were laid down they have been washed by rains and rivers and broken up by heat and cold and so eroded away from large areas where they were once present. Like the older rocks to the northeast they extend west of the area in which they are the surface bedrock and they underlie the younger rocks to the southwest.

At several different times after this western Iowa was covered by the ocean or by great fresh-water lakes, over the floors of which were spread the different strata which now form the bedrock of that part of the state. Then for a long time Iowa was dry land and was subjected to all the destructive forces of Nature, which were carrying away the rock strata, cutting deep valleys into level plains and making a diversified landscape of what had been a flat seafloor. But finally there came a change in climate and in other conditions which brought about one of the most marvelous series of events of which this world has knowledge, the development and spread over northern America and Europe of a succession of immense continental glaciers which buried the frozen lands beneath a cap of ice thousands of feet in thickness.

HISTORY OF THE MANTLE ROCK

The Great Ice Age, also known as the Glacial Period or the Pleistocene Epoch, was a time when at several centers in Canada ice accumulated from the excess of winter snowfall over summer melting, and in time formed such great bodies that their own weight forced them to spread out in all directions over the surrounding country for hundreds and even thousands of miles. Over hills and valleys these great ice sheets advanced, across lakes and rivers they pushed in resistless might, until they had covered practically all of Canada east of the Rockies and had spread into the United States as far south and west as Ohio and Missouri rivers. Not once nor twice merely did these conditions recur, but five times the great glaciers came down from the north and melted away and disappeared. As each one pushed outward it carried with it immense loads of rock, gravel, sand and clay, which it had scraped and ground from the surface over which it passed. When the glacier melted back these loads of material were left behind, spread out over the surface as a sheet of glacial drift or piled in lines of irregular hills called moraines. Every one of the five glaciers entered Iowa and left its record in the drift which it deposited as well as in other ways. Therefore Iowa is classic ground for the study of glacial phenomena. The different glaciers and the drift sheets which they left are known by the names of the states in which they are well exposed or where they were first studied. Thus the first of these glaciers is called the Nebraskan and the deposits which it left are known by the same name. These deposits have been everywhere covered by later glacial drift sheets, hence their presence is known only by their being uncovered here and there by excavations, natural or artificial. After a long occupancy the Nebraskan glacier melted away and an interglacial period of warm climate followed. During this time herds of elephants roamed our prairies and forests, camels and sloths, horses and bears were abundant, and multitudes of other animals more or less familiar to us today, made their homes in the ground or above it. But again, after many thousands of years, arctic conditions prevailed and a second glacier, the Kansan, swept down from its gathering ground west of Hudson Bay and stretched its mighty length across Iowa southward to Missouri river. The material brought and left by the Kansan glacier, the Kansan drift, now forms the surface drift over nearly all of southern and western Iowa, and in the Camp Dodge quadrangle is found south of Raccoon and Des Moines valleys. See also the map of the drift sheets, figure 10. We have no means of knowing how long the Kansan glacier covered Iowa, although doubtless the time is to be measured in thousands of years. We do know that the succeeding interglacial interval, like the one which preceded the Kansan, was very, very long, long enough for the upper part of the drift to be thoroughly altered by having some elements dissolved and carried away by water while other parts were changed in character; long enough afterward for the level plain of the state to have carved into it a rough and rolling topography

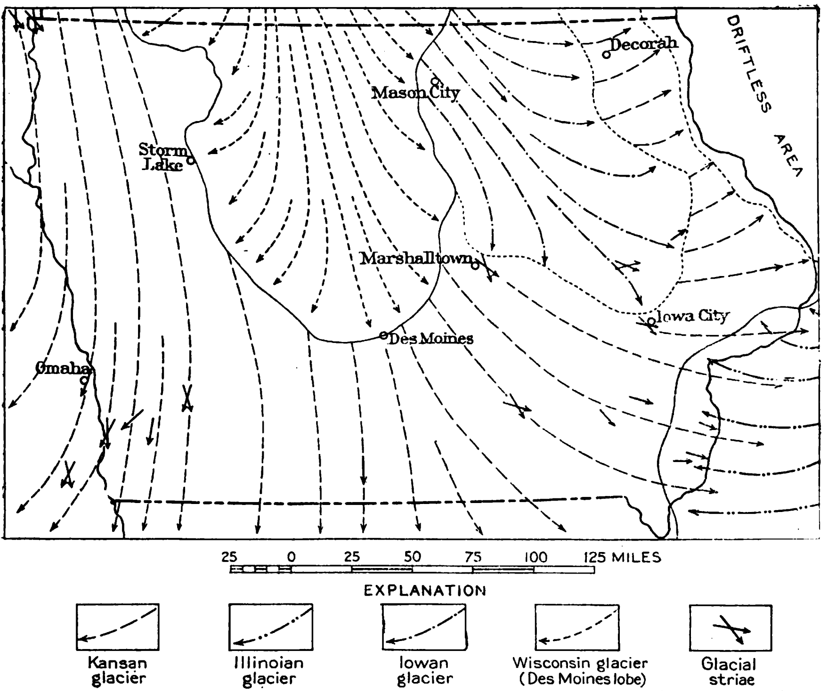

FIG. 10—Sketch map of Iowa showing the areas in which the different sheets of glacial drift are exposed at the surface, also the directions in which the glaciers moved as shown by striations made by the ice on the rock over which it passed. The Nebraskan glacier is not represented on the map, but it probably covered the entire state. It was later overridden by the succeeding glaciers.

similar to that shown on the southern part of the Camp Dodge map. The animal and plant life of this time was quite similar to that of the preceding interglacial time. Some forms were very similar to those of today while others were very different.

The next glacier, the Illinoian, came from a center in far-off Labrador and invaded Iowa from the east. Only the edge crossed Mississippi river, between Clinton and Fort Madison. The period of warm climate which followed this invasion was of shorter duration than the preceding ones had been, and then a fourth glacier, the Iowan, came from the north and spread out its sheet of drift. This is exposed only in northeastern Iowa and is notable for its thinness and for the immense bowlders which are scattered on its surface in some counties. Following a fourth interglacial period the fifth and last glacier of the series, the Wisconsin, advanced over central Iowa and covered the Des Moines valley as far south as the forks of the Raccoon. As it in turn melted away it left its load spread out as a level plain or here and there heaped into ridges very much as they exist today; altogether giving us an accurate picture, no doubt, of conditions as they were at the close of each of the older glacial occupancies. Upon this level plain there were distributed innumerable ponds and lakes, many of which have persisted to the present day, while other parts of the plain are still so level that natural drainage lines have been but poorly or not at all established and swamps and sloughs occupy much of the surface—or did until man began to hasten the processes of Nature. These various features are well shown in the northern part of the Camp Dodge quadrangle.

It was stated above in speaking of the soils of our area that most of the mantle rock consisted of a yellow or gray pebbly clay. It may now be said further that the typical unmodified Nebraskan drift is dark gray or blue-gray and contains some but not a great many pebbles. It is not likely to be encountered in many places in the Des Moines valley, although its presence there is known. The Kansan drift is more likely to be found and is typically a bluish pebbly clay which is changed by weathering, the process of alteration previously described, to yellow in its upper parts. These features are well shown in ravines and elsewhere south of Raccoon valley, where this drift is exposed. The Wisconsin drift was originally a gray clay with many pebbles of limestone and other kinds of rocks and with much lime in fine powder mixed with the clay. In its upper part it too has been changed by weathering to a yellow, and nearer the surface to a brown color, and some of the lime has been removed by solution. The upper foot or so, of course, is blackened by vegetable material, and in swampy places peat has accumulated on the clay. This Wisconsin drift is the surface material over all the Des Moines valley region north of Des Moines. See figure 10.

There is in western Iowa and around the border of the Iowan drift a deposit called the loess (pronounced **lurs**). This is really a wind blown dust and was derived, in western Iowa from the flood-plain of Missouri river, in eastern Iowa from the surface of the Iowan drift soon after this drift was laid down by the melting away of the Iowan glacier and before vegetation had covered it. The loess is present also on both sides of Des Moines valley, whence it was blown by winds, probably while similar beds were forming elsewhere, at the close of Iowan glaciation. The significance of the deposit in the present connection is that it is present under the Wisconsin drift at different places in and near the Cantonment, in the city of Des Moines and elsewhere, and also forms the surface material over the Kansan drift south of Raccoon river, except where it has been washed off the slopes or where wind blown sand covers the surface. Thus it was penetrated at a number of places in excavating for sewers and cellars at Camp Dodge, where a few feet of black soil grading below to brown clay overlies the loess. One of the best examples showing the presence of the loess near the Camp is a well on top of the ridge in section 14, Jefferson township, near the northeast corner of the Cantonment Reservation. This well passes through eight feet of sand, then through twenty-five feet of yellow pebbly Wisconsin drift clay and below this through twenty-seven feet or more of loess. Beneath the loess there may be the Kansan drift, or possibly the loess rests directly on the Coal Measures, which form the core of this ridge.

The loess differs from the drift in being very fine textured, pebbleless, typically without any sand even, and in having a plastic, doughlike structure, so that it can easily be moulded when it is damp. In color it is typically yellow or gray, although in the well just described the color was a dark blue. The loess ordinarily contains considerable lime in fine flour or as small balls and knobs and where it is fresh and unmodified small snail shells are very likely to be present. It has the remarkable quality of maintaining vertical faces in exposures, even for many years and where it is subject to adverse climatic conditions, whereas drift clays will slip and slump down into long gentle slopes. The writer has seen walls of loess twenty-five feet in height which were still vertical after standing for forty years. The significance of this quality in trenching work will be readily appreciated. In spite of its fine texture it is quite porous and water passes readily through it. Trenches and similar excavations in the loess would be readily drained if they were above water level.

HISTORY OF THE VALLEYS

There is evidence that the valleys of the two chief streams of the region—the Des Moines and the Raccoon—and also the valley of Beaver creek in our area—are older than the last glacial age and that these valleys were partly filled but not entirely buried by the clays and gravels of the Wisconsin drift sheet. The few last miles of such streams as Walnut, Big and Fourmile creeks occupy valleys which also were in existence before the Wisconsin glacier came down, but the upper parts of these streams meander over the surface of the Wisconsin drift-plain in valleys which are yet in the making. On the other hand the evidence also indicates that none of these stream courses were in existence when the first glacier advanced from the north, that they have all developed during the intervals between the glacial occupations of this region. The Des Moines and Raccoon valleys, and this may be true for the valleys of their larger tributaries also, began their development after the melting away of the Nebraskan ice sheet, that is during the succeeding period of warm climate. The Raccoon doubtless occupied its present valley but the modern valley of Des Moines river is quite different from the original one. Between the city of Des Moines and the Mississippi the ancient valley coincides with the modern one. The northward continuation of the ancient valley is beneath the wide flat between Capitol and Highland Park Hills on the west and the Fair Grounds and Grand View Park on the east; it extends across the low level area in western Saylor township (see figure 11 and the map) and stretches away to the northwest along what is today Beaver valley. The valley at present occupied by the river north of Beaver creek was cut out after the retreat of the second, the Kansan glacier. The very narrow section of the valley extending through the main part of Des Moines is thought to have been cut out during the Wisconsin ice invasion. That is, it just precedes the beginning of modern, postglacial conditions.

Since the Raccoon valley lay at the margin of the Wisconsin ice it was not much modified by the Wisconsin drift or by water-borne materials—gravel, sand and other products. But the Des Moines valley was entirely buried by the ice as far as the mouth of Raccoon river, hence it was partly filled by ice-borne and water-carried materials. Most of these have since been cut away by the river but remnants are still present as clays, sands and gravels filling the valley bottoms and as terraces of similar materials along the valley walls. The original valley of the Des Moines, which is now occupied by Beaver creek, probably was never entirely filled with drift material and so doubtless was occupied by Beaver creek following both the Kansan and the Wisconsin ice invasions. Other tributaries were only partly filled by the Wisconsin drift-sheet, especially near its edge, where both the ice and the load it carried were thin, hence they offered favorable channels for streams. In the centuries since the ice left our region these streams have worked back on to the prairies, using sags and irregularities in the surface to extend their courses, although there are yet extensive areas where their control is very slight. A similar history has been passed through by the smaller streams which have had to form their courses from the beginning in postglacial times. They have cut gullies in the walls of the larger valleys, these gullies have been enlarged to ravines, then to valleys occupied by wet weather streams, and finally in the case of some the streams have become permanent, flowing the year around.

THE PRAIRIE PLAIN

With the history of the topography of the Camp Dodge region in mind it will now be clear why it is that most of this region is a nearly level or gently rolling plain. This prairie plain is the slightly modified surface which was left by the great Wisconsin glacier. It stretches away in endless reaches to the north across Iowa, across Minnesota and into central Canada. It is marked nearly everywhere by similar characteristics: A surface which varies from monotonously level to gently rolling with here and there a rougher aspect where it breaks into a morainic tract; an abundance, in most localities, of swamps and sloughs, some of which may be large enough to merit the dignity of being

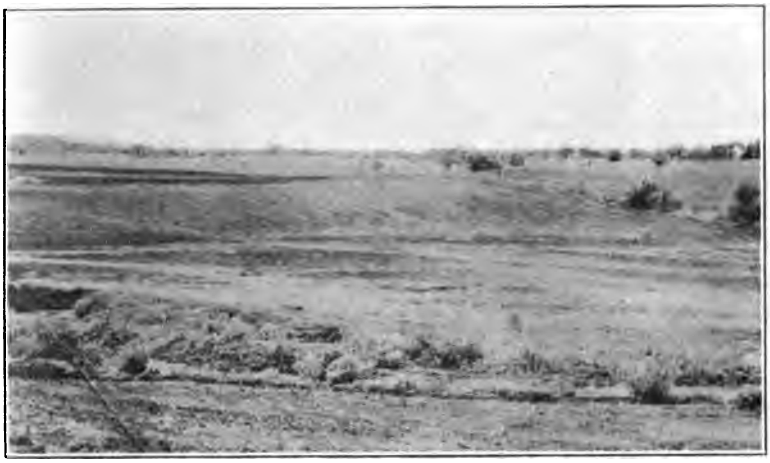

FIG. 11—Looking northwest up Des Moines valley from the road in the southeast quarter of section 15, Saylor township, north of Highland Park. This shows the portion of the old valley of the Des Moines which is crossed by the modern river. Note its great width, here about three miles, and its level surface. It is filled with sand and drift to a depth of seventy-five to one hundred feet. The point of the ridge between the present valley of Des Moines river and the ancient valley, now Beaver valley, may be seen in the left background.

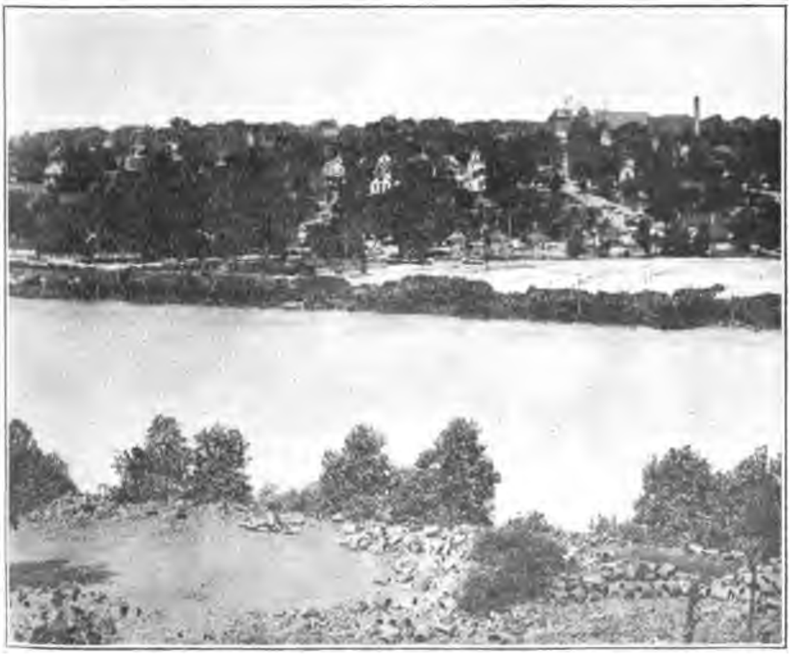

FIG. 12—Looking west across Des Moines valley in the city of Des Moines, just above the plant of the Iowa Pipe and Tile Company. The view is from the edge of the bluff on the east side and shows the very narrow gorge and the steep west wall. The buildings of Mercy Hospital crown the bluff at the right. This part of the valley is thought to have been cut while the Wisconsin glacier lay just to the north.

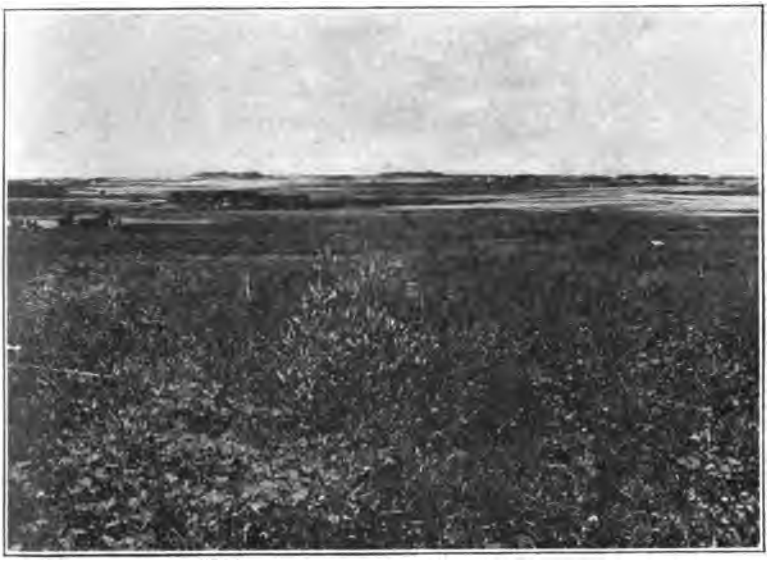

FIG. 13—Looking northwest across the Artillery Range, north of Camp Dodge. The view shows the typical level topography of the Wisconsin drift-plain and the very gentle slope of the east wall of Beaver valley which flattens out in this region.

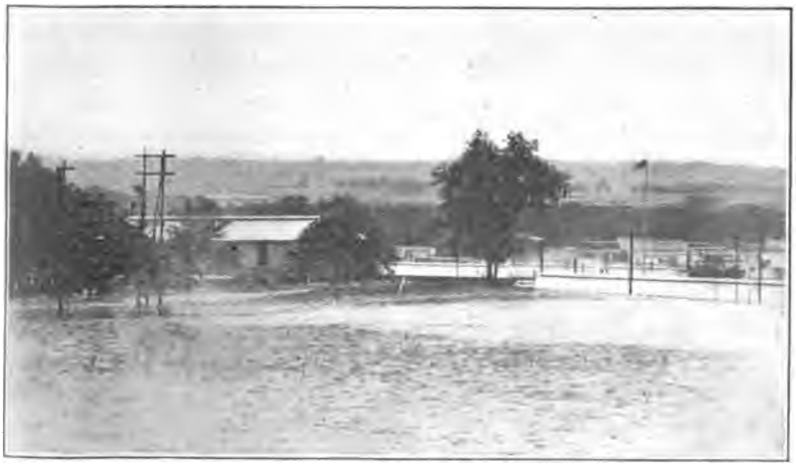

FIG. 14—Looking west across Camp Dodge and Beaver valley at Division Headquarters. The gently sloping west wall of Beaver valley and the level skyline of the Wisconsin drift-plain are visible beyond the Camp.

termed lakes; streams relatively few and most of these in shallow valleys save in the immediate vicinity of the master streams, the larger rivers. The plain near Camp Dodge shows these characters typically developed. East of Des Moines valley it is almost everywhere gently rolling and is dotted by multitudes of depressions which the natural drainage lines either have not yet reached or because of their low gradients have not succeeded in draining thoroughly. These features are especially well shown in Lincoln and Elkhart townships and farther north, where only the headwaters of the streams have yet penetrated. Nearer the valleys of the Des Moines and the lower parts of its larger tributaries erosion, the cutting away of the land, has proceeded far enough to have reached and allowed the drainage of these depressions. Consequently those areas in the northwestern part of the quadrangle which border the river are fairly well drained. The same is true also of Crocker and Saylor townships, and, farther east, of the territory which is drained by the lower reaches of Fourmile creek. The headwaters of this creek as well as of Rock creek, Big creek and other streams farther north, have not yet become effective as drainage elements.

On the west side of Des Moines valley surface conditions are somewhat different. There is very little of the "saucer" type of topography—the shallow, undrained depressions—within the limits of Camp Dodge quadrangle. This is probably due to several causes. In the first place the Wisconsin drift of Webster township in Polk county and of Walnut and southern Grant townships and the region farther west in Dallas county was laid down as a smooth, level drift plain rather than as an undulating, hummocky plain like that east of the river. In the second place the valleys of Des Moines and Raccoon rivers and of their tributaries, particularly Beaver and Walnut creeks, afforded some drainage lines for the plain from the first.

If the reader will examine that part of the map south of Raccoon and Des Moines rivers, he will be impressed by the crowded condition and extreme irregularity of the contours, which indicate a rather strongly rolling country with very little of the original level upland remaining. This, it will be remembered, is a part of the Kansan drift-plain and its topography is quite characteristic of that plain as it is found in southern Iowa. Numerous valleys extend across it and from these many smaller ravines and gullies head back on the slopes of the dividing ridges.

It offers a notable contrast to the level or marshy Wisconsin plain about Camp Dodge.

The higher parts of the Wisconsin drift-plain—the areas between the streams—the divides—range from about 965 feet above sea level in the vicinity of Saylor Station, and 980 feet in the west part of Des Moines to 1,000 on the crest of the ridge at Camp Dodge and at Ankeny, 1,010 feet west of Grimes, and 1,040 feet near Waukee and in the north part of the area covered by the map and to 1,060 feet in western Grant township, Dallas county. The positions and altitudes of these localities show that there is a gradual rise of the plain to the north and a somewhat steeper rise to the west and northwest, although this rise is more notable some distance away than within the limits of the topographic map.

The Kansan plain to the south of Des Moines does not rise quite so high as does the Wisconsin plain to the north. This is due in part perhaps to the lowering of the plain by erosion, but more to the natural slope to the south and east which is common to all of this part of the state.

THE MORAINE

It was stated above that some of the load which the glaciers carried was left piled up in lines or groups of irregular hills called moraines. In Iowa these moraines are better developed in connection with the Wisconsin drift-plain than on any of the other drift-plains. Where the margin of the ice stood nearly stationary for some time on account of melting, the clay, sand, gravel and bowlders which were being continually pushed forward by the onward moving body of ice would be piled up in great mounds near the edge of the glacier or would be carried away by streams from the melting ice. Such periods of a stationary margin occurred.during the advance of the glacier, while it was at its maximum extent and while the margin was being melted back. The accumulations formed during the advance might be leveled off by being overridden by the ice, those formed during the greatest extent of the ice would form a terminal moraine around the edge of the drift sheet and those formed during halts in the retreat of the margin are the recessional moraines. Because of the fact that there were always great quantities of water flowng from the ice edge, a good deal of the finer materials would be washed away and a large proportion of the material

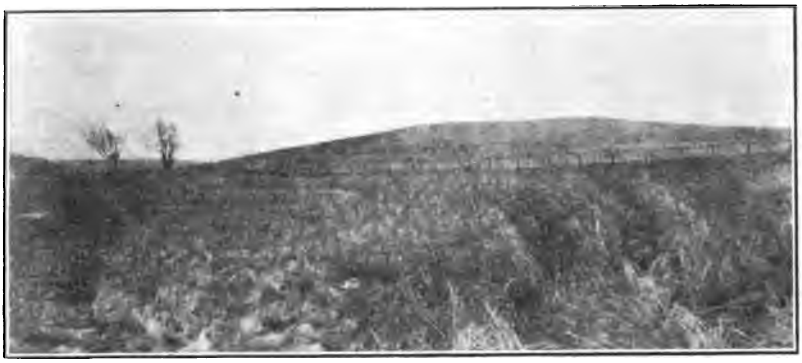

FIG. 15—The morainic knob in the swamp in Beaver valley just south of the road in the center of section 19, Jefferson township, Polk county.

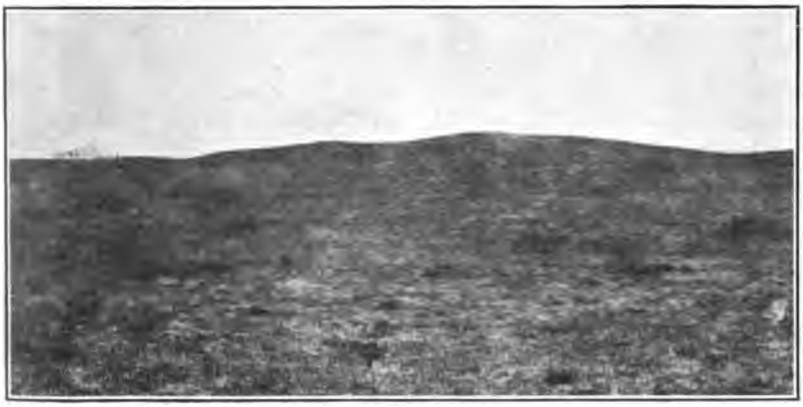

FIG. 16—Morainic hills on the south slope of Beaver valley in the south part of section 24, Grant township, Dallas county.

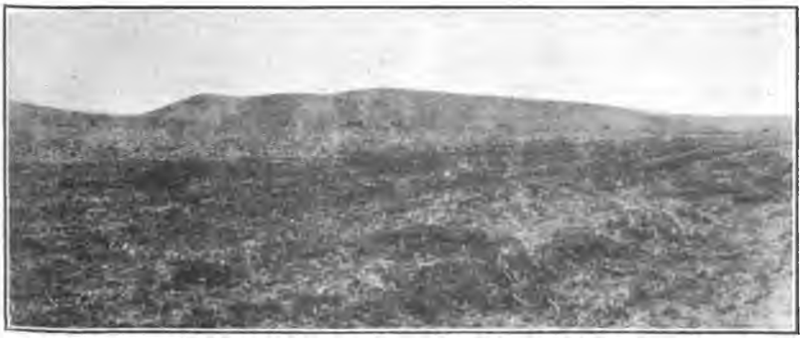

FIG. 17—A morainic hill at the south edge of Beaver valley near the west line of section 24, Grant township. The hills shown in these three views are parts of the Camp Dodge moraine.

forming the moraine would naturally be relatively coarse as compared with the bulk of the drift sheet in more level areas. Hence the morainic hills of the Wisconsin drift region are mainly gravelly or bowldery and both because of their sloping sides and because of this coarse nature their surfaces are less fertile and have less vegetation covering them than is the case with the level prairie lands.

For some reason there is no terminal moraine at the southern extremity of the Wisconsin drift-plain, though it is well developed along the west margin and to some extent along the east side. There are several recessional moraines, some of which are well marked. One of these lies in part within our area and a portion of it is shown on the topographic map. This moraine we may call the Camp Dodge moraine. It extends from north of west to south of east across Grant and Jefferson townships and most of it lies on the south slope of Beaver valley. On account of this position the moraine does not rise much above the neighboring uplands, but it has the effect of roughening the topography considerably, as the map shows. Besides the moraine on the south side there are some morainic hills on the north side of the valley, of which that east of the center of section 34, Des Moines township, Dallas county, a large one just east of Granger and one two miles northeast of Granger in the center of section 31, Jefferson township, are among the most noteworthy. They rise forty to one hundred feet above the lower lands about them. The main moraine consists of irregularly arranged groups of knobs and hills which rise twenty, forty or sixty feet above their surroundings and some of which are closely grouped while others are more widely scattered over the drift-plain. Most of these hills rise quite steeply from their bases and many of them are of rough profile rather than of the smoothly rounded type of hills which are the product of erosion by running water. As has already been indicated they bear no close relation to the streams, that is, it is evident on close examination that their positions and shapes were not determined by present day streams or running water. Rather have they themselves had much to do with determining the position and direction of such stream courses as have been formed among them. It may be noted incidentally that the situation of the moraine on the long slope of Beaver valley has been influential in establishing the drainage of the moraine sooner than would have been the case had it been built up on the level prairie away from such a well developed valley.

The ponds and swamps in southwestern Jefferson township within the valley of Beaver creek itself are due to the presence of this moraine on the valley floor. The knobs and depressions of the moraine have had a retarding effect on the drainage of the lowland. The swampy areas north of Beaver valley are doubtless due to the development of the saucer type of surface, similar to that east of Des Moines valley already described.

On the east side of Des Moines valley from the latitude of Ankeny northward past Crocker and as far as the latitude of Alleman at least there are evidences of the recessional moraine. These are indicated on the topographic map by the short closed lines of more or less irregular outline marking the low morainic knobs which are interspersed among the more level swampy areas. This is quite characteristic of morainic districts, which are as a rule only poorly drained, especially where they are situated upon what would otherwise be a fairly level plain, such as the Wisconsin drift-plain. The moraine is not so well developed or so prominent on this side of the river as on the west side, but there can be no doubt of its presence, especially as one examines the area in the field. The shapes of the hills and their lack of relation to the streams mark them as being of morainic origin and nature. Gravel pits have been opened in some of them and these reveal the coarse nature of their materials.

THE VALLEYS

Into the gentle sloping Wisconsin drift-plain the valley of Des Moines is cut 160 to 200 feet. The immediate slopes of the valley are for the most part quite steep and rise 100 to 140 feet above the bottom lands, the flood-plain, as it is called. Beyond the crests of the bluffs the rise is more gradual to the uplands. Below High Bridge the valley floor widens gradually until opposite the Camp it has a width of a mile or more. But in the vicinity of High Bridge and to the north as far as the limits of the map it is narrower, so that the flood-plain is scarcely more than a quarter of a mile wide and in places is less than this. The narrowness of this part of the valley is due to the fact that for some reason the restraining walls, which here as elsewhere consist of shale with some thin bands of sandstone and limestone, have never been cut back through all the career of the valley.

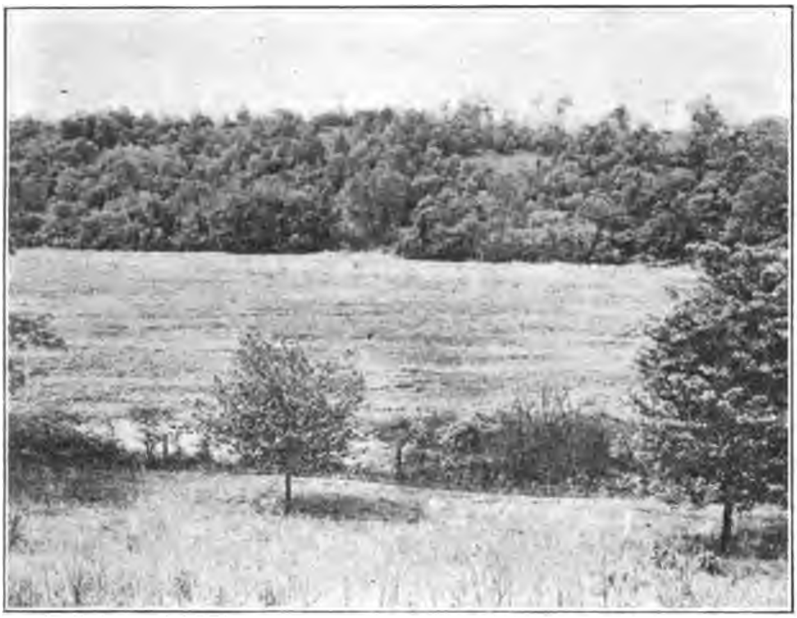

FIG. 18—The narrow flood-plain of Des Moines river just below Scandia bridge one and one-half miles above High Bridge. Looking west from the east wall. The space between the fence in the foreground and the trees in the background represents the entire width of the flood-plain—about two hundred yards. The river flows at the foot of the farther bluff.

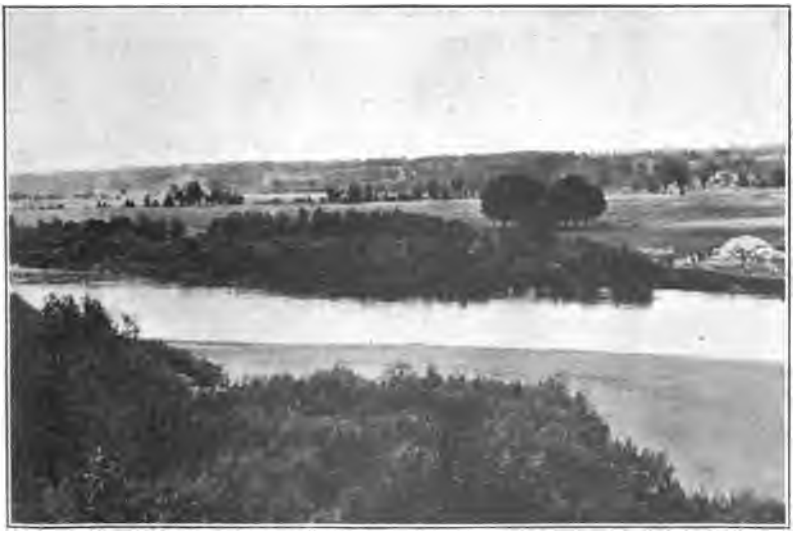

FIG. 19—Looking northeast across Des Moines valley from the west side in the southeast quarter of section 10, Jefferson township. The view was taken from the top of a gravel terrace about seventy-five feet above the river. Note the sand in the foreground, the flat flood-plain and the steep wall in the background.

Between High Bridge and the mouth of Beaver valley the Des Moines valley had reached its present width before the oncoming of the Wisconsin glacier. The gravel, sand and clay which were carried by this glacier and the water issuing from it partly filled the valley and since the glacier left the region the river has been busy washing down and carrying away this valley filling. It has succeeded in removing much of it but some remains in the valley bottoms, building them up to heights of thirty to forty feet above the original valley floor. Considerable amounts are present also as gravel terraces which flank the walls as narrow strips or as wider flats. These terraces rise twenty-five, fifty or seventy-five feet above the flood-plain, showing that the valley was filled to the level of the highest of them by the material from the Wisconsin drift. One of these terraces occupies the southwest part of section 29, Jefferson township, and a smaller one faces the long loop of the river in section 33, a mile farther southeast. The largest one in our area, however, lies in sections 4, 3 and 10, just north of the old village of Andrews. Smaller ones may be found along the slope of the ridge in sections 25, 30 and 31, opposite the Camp. It is the presence of these remnants of the valley filling that shows that the valley was as wide before the Wisconsin glaciation as it is today, that most of the river's energy has been spent in clearing away this waste from the Wisconsin ice sheet.

Where the river crosses its old valley in Webster and Saylor townships (see page 31) it has, of course, a very wide, low, flat flood-plain in which it has cut numerous meanders which are now marked by oxbow lakes and ponds and other depressions. South

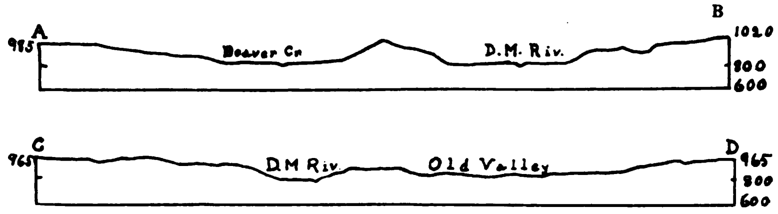

FIG. 20—Cross sections showing the comparative shapes and sizes of the former and the present valleys of Des Moines river. A-B. Profile from the south line of section 33, a mile and a half east of Grimes, northeast across Beaver valley, the ridge on which Camp Dodge is located, the modern valley of Des Moines river and the uplands as far as the southwest quarter of section 16, Crocker township. C-D. Profile from near the center of section 31, Des Moines township, northeast across the upland, the narrow valley of the Des Moines, Highland Park Hill, the wide abandoned valley of Des Moines river and up the slope to the northwest quarter of section 18, Delaware township, on the summit of the ridge between Des Moines and Fourmile valleys.

of this wide flat the valley is increasingly narrow to the mouth of the Raccoon, below which point it widens abruptly and greatly so that in the southeast part of Des Moines the river is flowing in a valley two to three miles wide—the original post-Nebraskan valley.

The next largest stream of the region, Raccoon river, occupies a wide, flat-floored valley which has been filled to considerable depths with sand and gravel from the Wisconsin drift. It seems probable that this valley has not been seriously affected by glaciation since the beginning of its history, following the end of the Nebraskan glacial stage. Its walls are in part glacial drift and in part shales of the bedrock series, the Coal Measures.

The other large valley of the region, that of Beaver creek, as has been noted is older than the present valley of Des Moines river. Its great width and gentle slopes are due in part, no doubt, to the great length of time during which it was occupied by Des Moines river, during the first interglacial age. During this long period the river was swinging from side to side of its valley, constantly cutting its walls and widening its flood-plain. Hence by the time the Kansan glacier covered this region the valley had been developed to large proportions. The Kansan glacier partly filled the ancient watercourse with clay and sand and gravel so that it was abandoned by the river and its floor was elevated somewhat above the present-day floor of Des Moines valley. But all through the ages ice and rain, frost and heat have been wearing away the walls of Beaver valley, making them continually smoother and more gently sloping. The wide flats in western Saylor and in Lee townships already mentioned as being part of the ancient Des Moines valley have similar characteristics. Their side slopes for the most part are very gentle, the bottoms are flat and the floors are built up to a height of nearly a hundred feet with waste materials—silt and sand—which have been carried in by moving ice and flowing water.

The lower valleys of Walnut, Fourmile and Big creeks are worthy of mention here because at first glance they seem out of all proportion with the streams which occupy them. Their floors are one-fourth mile or more in width and the walls are high but show evidences of a long history in their gentle slopes and smooth contours. As has been stated before they, in common with the larger valleys, no doubt were in existence long before the Wisconsin stage of glaciation and so have passed through a similar experience, though on a smaller scale and for a shorter time, than that just outlined for Beaver valley.

THICKNESS OF THE DRIFT AND ROCKS

On the level upland plain the glacial drift has thicknesses which in places reach nearly 250 feet, although in many localities the thickness is somewhat less than this. Probably an estimate of one hundred feet will not be far from the truth as an average for the thickness of the mantle rock in our area.

The Wisconsin drift, which forms the upper part of the mantle rock, is not very thick, averaging perhaps twenty to thirty feet in thickness. Beneath it the loess is present in many places, although it is not universal in distribution, as it was washed away from much of the surface before the overlying drift was deposited. Its thickness differs greatly from point to point and in places amounts to twenty-five feet or more. Below it lies the Kansan drift, which again differs greatly in thickness, ranging from little or nothing to two hundred feet. Quite commonly there is present under this drift a bed of sand and fine gravel and locally there may even be found a remnant of the earliest drift sheet, the Nebraskan. Under all of these lie the Coal Measures, the bedrock of this region, with their alternating shales and sandstones and limestone layers and coal beds. Like the beds above them the Coal Measures differ in thickness from place to place, both because of irregularities in the floor on which they were laid down and because of similar irregularities in their own surface. The above statements will make it clear that in sinking any kind of excavation, be it well or trench or mine, no regularity of the strata can be expected, hence no assurance of just the conditions to be met can be given. For example, on the slopes of Beaver valley, within the limits of Camp Dodge, there were penetrated at one place a foot and a half of black soil, then one and one-half to two feet of brown, pebbly Wisconsin drift clay and under this gray and yellow loess, into which the excavation was sunk for two feet. At another locality the Coal Measures shales were reached under three to six feet of brown clay. The record of the well on top of the ridge, which was mentioned on page 30, gives an idea of what is present there. A prospect hole put down in section 2 of Saylor township from a surface elevation of 935 feet penetrated 130 feet of soil and drift before reaching bedrock, while some wells near Ankeny have been sunk into the drift as much as 200 to 240 feet from elevations of 980 to 1000 feet above sea level before they reached bedrock. As indicated by these records the surface of the Coal Measures here ranges in altitude from 740 to 880 feet above sea level. Near Corydon bridge it is about 900 feet above sea level and at several points in Des Moines it lies about 860 feet above sea level.

CLIMATE

The climate is one of the most important of the factors which determine the habitability of a region. Given a climate which includes the greatest extremes, of either heat or cold, of drought or moisture, and the highest development of civilization is impossible. It is in the regions of temperate heat and moderate rainfall that the greatest progress has been made. Applying these principles to the Camp Dodge region it will be seen that they have had a large influence in determining its prosperity and the high stage of development which it has reached. True the range in temperature is large, but it is not so large as to interfere very greatly or for long periods with the ordinary activities of city or country life. Neither is the rainfall so slight as to allow desert conditions or so excessive as to cause serious or widespread destruction. The climate of the Camp Dodge region, in common with that of the entire upper Mississippi valley, is of the kind known as continental. That is it is one which is subject to great variations from day to day and from season to season. It is not tempered by the more even conditions which prevail on and near the oceans. This climate is determined by the great cyclones or rotating winds which travel across the country from west to east. Some of these cyclones are many hundreds of miles in diameter and consequently affect large areas. They are not to be confused with the small violent tornadoes which sweep across limited areas and bring destruction to everything in their paths. These larger cyclones are caused by the air moving spirally toward areas of low air pressure. The air which moves northward from the Gulf of Mexico in these great spirals carries much moisture and as it is drawn into cooler regions it is obliged to drop some of this moisture as rain. The cyclones are followed by anti-cyclones, areas of high atmospheric pressure, which bring in cool dry air from the north or northwest. Hence the passage of one after another of these areas of alternating low and high pressure causes our changes of weather from wet to dry, from warm to cold. The weather conditions of autumn, winter and early spring are controlled very largely by these cyclonic whirls, but summer weather is influenced more by local conditions, which cause a considerable part of the rainfall.

As has been said the changes in temperatures of the Camp Dodge region are great. Summer temperatures often reach as high as 100° and higher points than this have been recorded. In the winter on the other hand the temperature often drops to 15° or 20° below zero and in extreme cases to 25° and 30° below. So the extreme range is 135° or more, while the average temperature is 23° above for winter, 73° for summer and 49° for the year.

The amount of rainfall in this region averages very well for the needs of the community. Most of the moisture falls during the spring and summer seasons when it is most needed. While the amount of precipitation during the winter is only about three and one-half inches, that during the summer is over twelve inches. The total rainfall during the year averages about thirty-two and one-half inches, very close to that for the state as a whole. Since upon the rainfall of a region depends in large measure its whole water supply, both surface and underground, the amount which our area receives is of most serious consequence and its consideration leads very naturally to that of the subject of water supply. This is one of the most vital problems connected with any region and one which is intimately related to the topography and the rocks of the area concerned as well as to the rainfall.

SURFACE WATERS

The chief possible source of surface water supply is Des Moines river with its large and never failing stream. There are great fluctuations in its flow but even in the driest seasons it never fails. On the other hand in spring seasons of heavy rainfall or after winters of heavy snowfall the river rises in flood and overflows its bottom lands. Much the greater part of the stream's flow is derived from beyond our immediate area, as is to be expected in a stream of such length—300 miles above Des Moines. Moreover there are but few tributaries which join the main stream within this region and these are nearly all small and insignificant. Besides, the basin which supplies the river is relatively narrow. On the east it is defined by a line extending from Elkhart a little east of south only two miles or so east of Fourmile creek. If we include the drainage basin of Beaver creek the western limits of Des Moines valley exclusive of Raccoon valley would extend from West Des Moines past Grimes and, farther to the northwest, past Minburn and Perry. Excluding Beaver valley from consideration the drainage area directly tributary to the Des Moines from the west is nowhere more than five or six miles wide. From this narrow basin it is not to be expected that there will be a great run-off or a large seepage of water, relative to the size of the main stream.

The second stream of consequence in this region is Raccoon river, which is but little less in size than Des Moines river. It is formed by the junction of the North, Middle and South Forks, which with their numerous tributaries gather the drainage from a large area of the east slope of the Mississippi-Missouri watershed in western Iowa. This insures a large and permanent supply in the lower course of the stream and the forks also are permanent along most of their courses.

The largest of the creeks of the Camp Dodge area is Beaver creek, which, while it is greatly inferior to the Des Moines or to the Raccoon, yet because of its length—sixty miles or more—and because of the size of its drainage area has a perennial flow which is worthy of consideration. The broad, gently sloping valley of this creek, which has already been described, draws to itself the drainage of an area which is nearly as wide as that directly tributary to Des Moines river, especially when we remember that so much of the basin of the Des Moines is as yet scarcely drained at all. While there are but few large creeks emptying into the Beaver there are numerous small streams which contribute to the larger stream's flow.

Walnut creek has cut its valley into the wide level plain between Beaver valley and the Raccoon and derives all of its supplies of water within the area herein discussed. Since its basin is not large its flow is limited and the upper reaches and the small upland tributaries go dry in the summer. The lower stream, having a wide, deep valley, has a permanent supply. On the eastern margin of our area Fourmile creek bears a similar relation to the plain between Des Moines and Skunk rivers and while it is somewhat longer and larger than Walnut creek its general characteristics are the same. Like Walnut creek it has the advantage of a wide, deep valley, which contributes much to a fairly large and permanent flow of water. Besides these creeks there are no other large streams in this vicinity. Big creek and Rock creek and Saylor creek are only a few miles in length and have relatively small and unreliable flows owing to their small catchment areas and their consequent quick response to weather conditions. The same is true to an even more marked degree of the numerous small tributaries of the Des Moines and of the large creeks which sooner or later contribute to the great river.

There are no lakes of large size within our area. Some of the abandoned portions of the Des Moines channel have been transformed into "oxbow" lakes by the closing up of their ends. Some of these are permanent while the smaller and shallower dry up during summers. On a smaller scale, similar conditions prevail in Raccoon and Beaver valleys. These "oxbows" are present only in the southern parts of our area where the valleys are wide and the streams in times past have swung from side to side of these valleys and then have shortened their courses by cutting across the loops, which then remain as "cutoffs" or "oxbows." The ponds and swamps of the prairies need scarcely be considered as they are too small and shallow to serve as dependable supplies of water, in large quantities at least. Besides, the quality of the water in these ponds would not be of the best and furthermore many of them are being drained and the land put to use.

GROUND WATERS

When we come to consider the underground waters of the Camp Dodge region we must think of them primarily with relation to their containing beds of clay and silt, of sand and gravel, of shale and sandstone, or whatever the nature of the water-bearing layers may be. Again we must take into account the nature of the topography and its relation to the underground waters. Taking up the second of these points first we shall find that the region may be divided into two provinces—the uplands and the lowlands, the prairies and the valleys. Now it is a simple and well known fact that the upper surface of the ground water, the water table, as it is called, is higher under the uplands and lower under the lowlands. But it is true also that under ordinary conditions the water table is not so near the surface under the uplands as under the lowlands. In spring or in very wet seasons, however, it may be at the surface in both localities. On the prairies again, the water table, while it rises in the hills, is not so near to their surface as to the surfaces of the lower plains. So the upper part of a hill may be entirely dry while at its foot a lake or a swamp may be kept filled by the ground water. Further, in the rough and rolling country bordering the streams where, because of the presence of numerous ravines and valleys and steep slopes, escape of the ground water is easy, the water table will be farther below the surface than in either upland or lowland. Again, as we know, the water table fluctuates with the weather and with the seasons. It is higher in the spring or after a period of prolonged rainfall and lower in the summer and in any other dry period.

Considering now the character of the rocks and soils and its relation to the ground water, we shall find that clays contain and transmit less water than do sands and gravels and that therefore, other conditions being equal, the water table will be lower in a clay region than in a sandy region. In order to reach water it will be necessary to dig farther into the clays of the glacial drift than into the sand beds of the valleys or even into those which are here and there present under the prairies. But this fact also illustrates the close relationship between topography, the character of the strata and the ground water. The upland sloughs have remained until today because the fine texture of the glacial clay permits it to act as a container rather than as a transmitter, and furthermore because the clay under these sloughs has become even closer textured by the fine material which has been carried into it by the water. Consequently there is very little movement of the ground water under those uplands where streams have not yet cut deep valleys, just as there is but little movement of the surface water here either along the ground or into it. The importance of these facts in relation to any military operations such as trenching, tunneling, road making, well digging and others, will be readily seen. Water will be encountered nearer the surface on level uplands such as those about Ankeny and west of Grimes than in the "breaks" of Des Moines valley, where the upland meets the steeper slopes. On such slopes, however, account must be taken of the possible presence of sand and gravel beds which may outcrop and which will then serve as channels for the escape of ground water and will affect operations accordingly. It will be understood from what was said above about the character of the mantle rock that sand layers or streaks may be encountered anywhere in the glacial drift and so their exact location cannot be foretold. But, except in those cases in which they occur above the ground water level, it may be accepted that wherever they are found they will be water-bearing and hence reckoning must be made with them. In the case of the strata of the bedrock it may be said that as a rule the shales are not water-bearing to any great extent, although a little water may be found seeping through them in places. The sandstones are much better water beds as their porous nature enables them to receive and transmit large quantities of water. Of course under the uplands the bedrock would not be reached except in wells and similar excavations.

In the valleys the ground water level is near the surface owing to the porous character of most of the material which covers the valley floors. The water here also has relatively free movement, hence the water table will rise and fall readily in response to weather and seasonal changes. Because of these conditions greater quantities of water will be found in the valley filling than in the more compact materials of the uplands. In small valleys which have not been cut down to grade or widened sufficiently to permit the accumulation of secondary material, such for instance, as Rock creek along nearly all its length, and many of the small tributaries of Des Moines river, there will not be found notable supplies of ground water, except as these valleys may have been cut into beds of water-bearing sand. The great flat sag of Webster and Saylor townships is filled with sands and silts to a depth of a hundred feet, and these are saturated with water nearly to the surface.

The ground waters of this region which are contained in the materials of the drift plain or the valley filling are of good quality and may safely be used for any purpose for which they are desired. This statement, of course, presupposes reasonable care in the exclusion of all possible source of contamination, such as barnyard and house refuse and surface waters which might not be suitable for use. It is true, however, that waters from the shales of the Coal Measures are likely to contain mineral and other ingredients which will render them unsuitable for any purpose. Some of the sandstone layers yield large supplies of water which is only slightly mineralized.

It may be stated in brief that many wells on the upland derive their supplies at depths of forty to sixty feet from beds of sand and gravel or from the loess, which is porous enough to serve as a good water bed. Others go deeper, as much as 150 to 240 feet to find a supply at the base of the drift. Some wells are drilled to layers of sandstone in the Coal Measures at depths of 250 to 460 feet and a well in Greenwood Park in the west part of Des Moines was sunk to a depth of 3,000 feet to reach a thick bed of sandstone which furnishes an abundant supply of water wherever it is penetrated. In such wells water rises high in the tube and in some cases even overflows. In the lowlands water may be reached at ten to fifteen feet below the surface in the sands and gravels which cover the floors of the valleys. The wide flat valley of Raccoon river is filled with porous sand and gravel which carry a large underflow. It is from this underflow that the public water systems of Valley Junction and Des Moines are supplied, the former by means of wells and the latter by means of an extensive series of water galleries or water chambers.

INDUSTRIES AND RESOURCES

The military as well as the economic importance of the agricultural and mineral resources of any region are beyond question. Their value in connection with Camp Dodge construction and maintenance will be plain at a glance. The fact, too, that the first rush of the German onslaught in 1914 was toward the great coal and iron ore fields of Belgium and France is extremely significant. Some of the most bitter struggles of the war have been fought for the possession of these fields and their retention so long by Germany has been an enormous asset in prosecuting her campaigns. Because of the favoring physical conditions which have been described above agriculture is the leading industry in the region about Camp Dodge. The rich soils of the Wisconsin drift-plain yield large returns to the farmer who is willing to apply brains and energy to their cultivation. The lack of drainage of some areas, as already described, is the chief drawback, and this is being overcome more and more each year, as artificial drainage and increased cultivation are gradually drying out the wet spots and lowering the ground water level. General farming is the rule, although nearness and ready access to the large and steadily growing market of Des Moines have encouraged intensive and specialized farming or market gardening. The muck and peat of the swamps, when these are sufficiently drained, make ideal soils for growing celery and such products.

Closely associated with the farming industry are the small towns and villages, whose existence and prosperity depend upon the success of the farming communities surrounding them. The numerous grain elevators, the large amount of freight and express business in farm products and the presence of such industries as the large corn canning factory at Grimes are abundant testimonials of the importance and value of agriculture in its various phases in this region.

The next industry in importance in this region is that of coal mining. Coal underlies most of the area we are discussing, even though it may not everywhere be in beds thick enough to be profitably mined. Hence the mining industry is not confined to one particular locality but is scattered all over the region, wherever conditions are favorable for getting at and removing the coal. Des Moines is an important mining center and some of the other localities where important mines have been developed are in the vicinity of Saylor Station, where several mines are in operation; at Enterprise; at High Bridge; at Zook, and at the two neighboring camps of Scandia and Phildia, which are near the river just north of the limits of the map; and at Dallas, three miles north and a mile west of Granger. These mines in the northern part of our area have all been developed within the last few years and indeed all the mining which is going on from the upland prairie is of comparatively recent development. It used to be said that no coal would ever be found away from the Des Moines valley, but today some of the largest mines are well out on the prairie.

Polk county has always been a leader in the coal industry. During the days of the first Fort Des Moines Captain Allen's men mined coal from a bed which outcrops in the banks of the Des Moines in the neighborhood of the Center Street dam. This was used in the army blacksmiths' forges but wood was so plentiful in the valley in the early days that coal could not well compete with it. However, since 1865 the industry has grown rapidly until now nearly two million tons are mined annually. Dallas county has not been a large coal producer until in recent years when the large mines near the river have put this county into an important position. Its output is now about half a million tons each year.

One of the most important industries of the Camp Dodge region is that of the making of Portland cement. And yet this industry is carried on by only one plant, which is located southeast of Valley Junction near the intersection of Park avenue with the Chicago, Burlington and Quincy and the Chicago Great Western railroads. When it is stated that previous to 1917 there were only three cement plants in Iowa, and that the value of their output exceeded five million dollars the importance of this Des Moines factory may be appreciated. The shale for the cement is taken from a coal mine nearby while the limestone is brought from Earlham, twenty-five miles west of Valley Junction.

The shales of the Coal Measures make high class burnt clay products—drain tile, sewer pipe, paving and building brick, roofing tile and other wares—and are being used extensively by several plants in Des Moines. Near Camp Dodge there are several along both sides of the valley west of Highland Park while several others are located in different parts of the city.

In their natural state these shales are of no value for either roadmaking or building materials. They will slake down to dust or mud on exposure to the air and weather. The sandstones, likewise, are too soft to serve as durable building stone and as road or concrete materials they are excelled in accessibility and convenience of handling by the sands and gravels of the mantle rock. If the shales are burned they make a durable road material and when subjected to proper treatment they form one of the important ingredients of Portland cement. The limestone beds are too thin and inaccessible to be worthy of consideration for either road work or building material.

The sands and gravels associated with the glacial drift furnish excellent and, in places, abundant supplies of material for use in road improvement, concrete making and other construction work. The best and most readily available supplies are in the valleys, where they have been sorted and cleaned by running water. The terraces and high-level benches along the walls of the Des Moines, the valley bottoms and even the channel of the stream itself furnish limitless quantities of these important materials. These terraces have been mentioned previously in connection with the description of Des Moines valley on page 45. The large terrace in sections 3, 4 and 10 of Jefferson township is being extensively utilized and large quantities are being removed for railroad and commercial purposes. The enormous amounts of sand covering the floor of Raccoon valley are drawn on extensively for construction material of high grade and several plants in Des Moines are occupied in pumping sand from Des Moines and Raccoon rivers beds. This sand deposit is the result of the erosion of the Wisconsin drift, which contains a good deal of such material. The larger creek valleys also contain sands and gravels which have been washed out of the pebbly drift clays.

The sandy layers of the drift are too uncertain in location to be of much service but the morainic knolls of Grant and Jefferson townships west of the river and those of Crocker and Lincoln townships on the east side are gravelly and some of them have already done service as sources of road or concrete materials. The fresher gravels of the Wisconsin drift region do not make as good road metal as do older, more rotted gravels, as the older materials pack better and so form a more solid, enduring roadbed. On the other hand the fresher and cleaner gravels and sands are preferable in all building work.

VEGETATION AND TIMBER

There is very little of the original prairie left in Iowa. Hence practically all of the vegetation of our region is introduced or cultivated. Some of the weeds are natives and the undrained swamps and a few other spots such as railway rights-of-way still support the types of plants which grew upon them before the white man's plow broke the virgin prairie sod. Slough grasses, bulrushes, wild rice and other native species still make their appearance wherever their haunts have been left undisturbed. Upon the cultivable prairies, however, widespread fields of oats, waving ranks of corn, the bluegrasses, timothy and clover have displaced the true prairie grasses and flowers. It is only in the woods and sloughs that one need look today for wild flowers and many of these are being destroyed by ruthless picking.

Iowa has always been a prairie state. The uplands have never, at least since the last glacial invasion, borne forests or timber of any extent. Only in the valleys and along the streams have the forests been able to obtain and maintain a foothold. Scattered groves of willows and cottonwood border some of the larger swamps and moist places, but with such exceptions the timber occupies only a fringe of the uplands on the margins of the valleys. Oak and elm, ash and elder, hickory and walnut, maple and willow make up the mass of the forest, while such shrubs as gooseberry and buckbush, dogwood and raspberry occupy the open spaces among the larger trees. It is a conspicuous fact that the bottom lands of the Des Moines and to a considerable extent those of Beaver creek also are practically bare of timber. Here and there is a patch or a fringe of trees which seek or can endure much moisture, but most of the trees seek the valley walls and the ravines, where they are beyond the reach of destructive floods.

ROADS AND BRIDGES

One of the most serious questions which army commanders must consider is that of public roads and railways, their adequacy as to number, physical condition and direction; the possibility of their improvement to render better service or of their demolition to cover a retreat or to retard the advance of the enemy. All of these are important problems and the roads of the Camp Dodge region will offer good facilities for the study and practice of these problems.

An inspection of the map shows that the Camp Dodge region is covered with a network of roads and, on a larger scale is well supplied by a system of railroad lines which center in Des Moines and render all of the neighboring territory tributary to that city as well as affording ready transportation in all directions. The Chicago-Denver line of the Chicago, Rock Island and Pacific Railway crosses the district near the south margin while from southwest and southeast, northwest, north and northeast come the various lines of the Chicago Great Western; Chicago, Burlington and Quincy; Rock Island; Wabash; Minneapolis and St. Louis; Chicago, Milwaukee and St. Paul and the Chicago and North Western Railways. In addition to the city electric railway lines the Perry line of the Interurban Railway extends along Beaver valley and serves the Camp while its Colfax line crosses the eastern part of our area and the Fort Dodge, Des Moines and Southern Electric Railway comes in from the north along the eastern part.

Many of the country roads are still built of dirt only, although some have been surfaced with gravel and a very few have been paved, such as Beaver Avenue and Merle Hay Road as well as a few streets which extend in various directions as far as the city limits. During dry weather a dirt road is quite satisfactory, provided, of course, that it is well cared for. But the best dirt roads fail in wet seasons and because of this certainty of failure at some critical time it is essential that all important roads be given a surfacing of some material which will keep them in serviceable order in all seasons and under all traffic conditions. The abundance of available material as described above, renders this improvement relatively easy in the Camp Dodge region.

Bridges are elements of great military as well as economic significance and hence it is worth while from both standpoints to note their number and position within the Camp Dodge area. In the vicinity of the Camp there are in Des Moines valley Scandia bridge, a mile and a half northwest of High Bridge and the Snyder bridge the same distance below that village; the Hanley bridge, three miles northwest of Camp; the Corydon bridge, opposite the south end of the Artillery Range; the Fischer bridge, just opposite the south end of the ridge between the two valleys; also the long, high railway bridge at High Bridge. All these bridges are of steel and all with the exception of the Fischer bridge cross the valley where it is relatively narrow. Hence in case of strategical operations they or their approaches could be defended with relative ease from the steep walls of the valley. Demolition of such bridges also would be relatively easy. Farther south there are the Euclid Avenue bridge, west of Highland Park; the Sixth Avenue bridge, south of that suburb; and the various bridges within the heart of the city, in addition to the numerous interurban and railroad bridges, and the railroad and public bridges across Raccoon river.

Of course the smaller streams are crossed by bridges at nearly every section line or wherever the roads approach the valleys. With the exception of the Sixth Avenue bridge, and the down town bridges, which are built of concrete, all the river bridges are of steel. Most of the bridges over the larger creeks also are of steel, although a few, such as the ones over Beaver creek on Beaver and Merle Hay roads and those over Big creek at Polk City, are built of concrete, and a few of the old wooden pile bridges still remain.

THE CAPITAL CITY

Des Moines, the capital and largest city in the state, with a population of 105,000, is the business and industrial center as well as the political Mecca of the region. Its needs form the basis for a wide range of industries, which, however, extend far beyond its own confines and serve a territory which is well nigh state wide. Besides the various industries based on natural resources which have been mentioned there are numerous others which contribute their share to the prosperity of the city. Manufactures of various lines, wholesale distribution of produce, groceries, machinery, automobiles, and many other classes, numerous printing establishments, and indeed all the activities which make up modern city life are found here in abundance.

Perhaps the center of general interest in the city is the beautiful State House situated on the crest of the hill overlooking both Des Moines and Raccoon valleys. Its magnificent golden dome is a landmark over the entire city and for the country round about. It is easily visible from the ridge on which Camp Dodge is built and can be seen from the prairies in any direction. The city's other public buildings, the numerous and noteworthy office buildings, churches, the Y. M. C. A. and Y. W. C. A. buildings, the fine system of parks, all these are contributing toward the end of making Des Moines a bigger and better and more beautiful city.

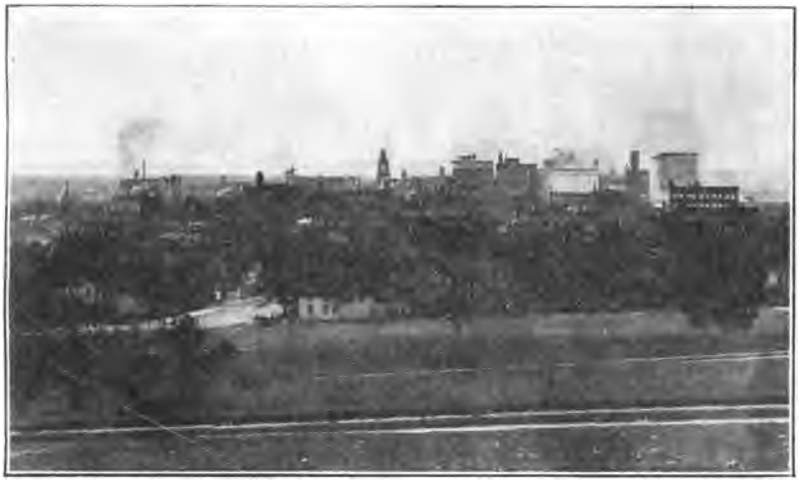

FIG. 21—Part of Des Moines' skyline as seen from the State House across the river. Beginning at the right some of the more prominent buildings are: The Capital City Bank building (with the awnings), the Equitable building (behind it), the Observatory building, the Valley National Bank building (the white one), the City Library (in front of it), the Fleming building, the Hippee building, the Post Office (in front of them) and the tower of the Court House. The valley of Raccoon river appears in the left background. The heavy smoke up this valley is from the Hawkeye cement plant.

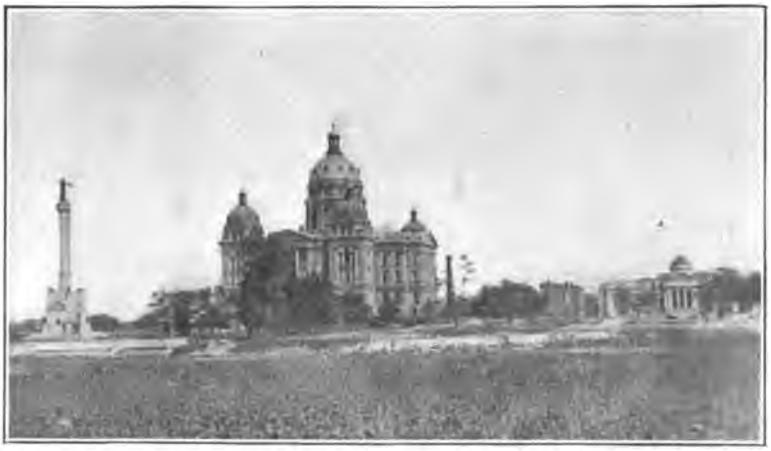

FIG. 22—The State House, the Soldiers' and Sailors' Monument, the Allison Memorial and the Historical, Memorial and Art Building; seen from the south. The view shows also a part of the enlarged Capitol Grounds, in course of improvement, including some of the Court Avenue viaduct, at the left.

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